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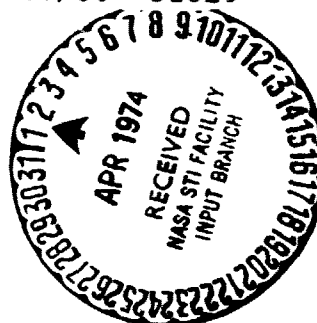
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## FROM HYPOTHESIS TO FACT: THE EARTH-MARS EXPERIMENT

Ye. Kodin and D. Pipko

People have called Mars the god of war due to its red appearance. I suppose this name is fitting: for many decades, an endless war of scientific hypotheses has swirled around this planet. It would seem that the flights of interplanetary space probes would dissolve the myth of the artificial origin of the "canals" of Mars; the seasonal changes in color of the planet, earlier attributed to "Martian vegetation," have been realistically explained as a result of the movement of masses of dust; the craters on the surface and the irregularity of form detected on photographs have overturned the attractive hypothesis of the "hand-made" origin of Mars to satellites -- Fobos and Deimos. But still, the "red planet" holds so many mysteries that only new, direct measurements, new data can calm the war of hypotheses. Today, the list of such data has been supplemented by information obtained by the next group of Soviet "Mars" automatic spacecraft. The first direct measurements of the parameters of the Martian atmosphere, made by the descent module of Mars-6 and transmitted to Earth, are of particular value.

After so many achievements of Soviet astronautics, these experiments might not seem so difficult. But imagine for a moment that the scale of our universe were reduced a billion times. Then, the distance from the Earth to Mars at the moment that the spacecraft arrived at the planet would be about a quarter of a kilometer, while the size of the target -- the diameter of the planet -- would be about 7 mm. Even an experienced sniper would have trouble hitting such a target.

But the "cosmic snipers" had a much more difficult task -- they had to send their spacecraft bullet to a predetermined point exactly 0.1 mm from the target. No further, no closer.

The problem is that although the escape velocity for Mars is only half that of Earth -- about 5.1 km/sec -- the descent module is braked very slowly as it enters the atmosphere. The atmosphere is simply not high enough to slow down the spacecraft on an ordinary descent trajectory ending in vertical descent. The reason for this is well-known -- the density of the atmosphere of Mars is some 150 times less than that of the atmosphere of our planet. If we were to simply open a parachute at high altitude, it would be immediately melted by the great descent velocity and torn to pieces by the air stream. However, if we were to wait until the speed decreased to the proper value on this sort of descent trajectory, it would also be no help: the atmosphere of Mars is so thin that we would be able to open our parachute only at a velocity of... minus 3 km or, in other words, beneath the surface of the planet.

Therefore, a combined method is used to bring spacecraft to the surface -- the descent module is directed not vertically downward, but rather at a slight angle to the surface of the planet. This causes the path of the spacecraft through the atmosphere to be greatly elongated, so that aerodynamic braking is sufficient to reduce the velocity to the point that the parachute can be opened without danger. To do this, the "cosmic snipers" must aim not at the planet, but rather at a point just beside it. The accuracy of this aiming must be fantastic: if the distance from the planet is too great, the descent module will simply fly past the planet, if it is too close -- the descent path will not be long enough to slow down the spacecraft.

How is the necessary accuracy achieved? Everyone today is familiar with the concept of trajectory correction: the



The photograph shows valleys hundreds of kilometers long. Their width in some areas reaches 80 km. Their wavy shape, reminiscent of the beds of terrestrial rivers, and the presence of systems of tributaries indicates that these formations probably were caused by water erosion. They connect a system of craters measuring up to 130 km in diameter, and we can see clearly the tracks where these beds enter the craters.

of a bullet a few meters from the target: the time required to transmit a signal in one direction -- from the Earth to the spacecraft -- is over 10 minutes. The station would simply fly by the planet during the time required for radio transmission of the signals.

To prevent this, the last correction was controlled by Mars-6 itself. After this, the program control device turned the spacecraft to the required position and the descent module was separated. After that, we could only learn about

position of the spacecraft is determined from the Earth using electronic devices and, after comparison with the calculated data, the necessary corrections are determined. But at great distances, the accuracy of determination of the position of the spacecraft, and indeed of Mars itself, is insufficient. The correction itself is made three to five hours before the approach to the planet, when the closing speed is several kilometers per second. Attempting to control the correction from the Earth is like attempting to change the direction

its "life" through the orbiting section of Mars-6: the descent module maintained radio communications with the orbiting section, which used its directional antenna to relay the information to Earth. During the experiment, after entry into the atmosphere, as the upper layers were penetrated, communications were interrupted for a short time: the plasma which formed around the descent module blocked the radio waves but then, as the descent speed slowed, communications were restored.

A no less complex problem was the "organization" of the parachute descent. A parachute jumper, as he leaps from an aircraft, opens his parachute at a falling speed of about 60 or 70 meters per second. As the descent module fell toward Mars, the parachute had to be opened at speeds two to three times the speed of sound. One of the most serious difficulties here consists in the fact that at these speeds a wake is formed behind the descent module, capable of twisting the parachute into a useless string. After many experiments, a unique solution was found to this problem: it was found that the undesirable results could be avoided by "shooting" the parachute slightly to one side of the zone of perturbation by means of a solid-fueled rocket engine.

The difficulties of studying Mars using automatic spacecraft are obvious. However, they have not discouraged the scientists attempting to learn the secrets of the "red planet." In the strategy of science, the modest term "study" is always followed, possibly distantly, by the more grandiose term "master." From this standpoint, it is easy to explain our interest in Mars: of all the planets of the solar system, only on Mars are conditions more or less like those on Earth. For example, a day on Mars is only 37 minutes longer than on Earth, the force of gravity is less by some 2.5 times, and the temperature on the equator in the daytime is an acceptable 20 to 25° C.

But beyond this, things become more difficult. The atmosphere of Mars consists almost entirely of carbon dioxide. It is 100 times thinner than our atmosphere and therefore easily penetrated by hard ultraviolet radiation from the sun, fatal to animal life! And finally, there is almost no water on Mars, the content of water vapor in the atmosphere being almost 1000 times less than in the atmosphere of Earth.



This photograph, produced by the Mars-5 spacecraft, shows a section of the surface taken from the center of the other photograph. We can clearly see a flat-bottomed crater 13 km in diameter. The photo also shows a large number of craters 2 to 12 km in diameter, only the smallest of which are cup shaped. The large craters have flat bottoms, and their slopes are greatly broken up by wind erosion.

volcanos, the scientists found... dry river beds on the photographs. In any case, it was difficult to think of another

From this we can easily understand the interest which scientists felt in the data transmitted by Mars-5, indicating that over certain areas the content of water vapor in the atmosphere of Mars reaches 60 microns - several times more than was earlier thought. We must recall here that after an earlier experiment, even stronger arguments were heard that Mars might have significant reserves of water. Photographs of the surface poured new fuel on the flames of the discussion: in addition to craters like the lunar craters and conical mountains reminiscent of

name for the meandering valleys and gorges with their many "tributaries" clearly seen on the photographs. Are not the new data yet another confirmation that rivers of water flowed on Mars in the distant past?

Of no less interest for scientists are the photographs transmitted by Mars-5 from the red planet. Although the photographs themselves cannot give us an idea of the variations in altitude of individual sections of the surface, if photography is combined with a measurement of the thickness of the atmosphere, some clarity is gained. From this standpoint, the importance of the data produced can hardly be over-estimated: they show that the variations in altitude on Mars are as great as several kilometers. Finally, the fact that the magnetic field of Mars is 7 to 10 times stronger than that in interplanetary space gives us a key to the understanding of the peculiarities of the internal structure of the planet.

Soviet science and technology have made yet another step along the trail of the study of space and the planets of the solar system. However, there is still much more unknown, and many more spacecraft will be launched toward the distant planets. Actually, it could be no other way: it is not by chance that mathematics widely uses the method of successive approximations -- complex problems cannot be solved in one try. To some extent, this method is also used in astronautics: the Luna spacecraft number 9 was the first to succeed in making a soft landing on the moon, the success of Venera-7 followed the parachute descents of three vehicles from Earth. We know: there will be new launches to Mars, to enrich terrestrial science with new facts.